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The Louis H. Bauer Lecture
Delivered by
James E. Webb, Administrator
National Aeronautics and Space Administration
at the
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"Exploration and Utilization of Space"

Mr. Chairman, Members of the Aerospace Medical Association:

Thank you for the opportunity to meet with you at this 33rd Annual Meeting of the Aerospace Medical Association. All of us in the National Aeronautics and Space Administration appreciate the pioneering work so many of you have done to help put Americans into space. We appreciate, also, the most important role you and your Association must play in achieving our national goals in space.

The three American astronauts who have penetrated beyond the earth's atmosphere and into space went up alone, but their calm assurance was due in no small measure to the fact that aerospace medicine had carefully prepared them and their equipment during years of painstaking and creative scientific investigation.

The astronauts, and the Nation which watched, knew that the risks involved in these pioneering flights had been cut to the irreducible minimum by the best engineering minds and medical talent this country could muster.

In addition, we all knew that every facet of each of these flights would be measured and recorded, and that not only those directly involved, but all of you, and many others in every area of science and technology, would have access to the data in order to study its implications, increase knowledge, and to apply it in a steady stream of improvements.

The language of the Space Age has many colorful expressions. One of them, which says much in few words, is the engineers' shorthand expression, "The man in the loop," to characterize a system that uses man's capacity and versatility to increase greatly the usefulness of the machines and devices employed.

You practitioneers of aerospace medicine, one can justly say, are the "men behind the man in the loop." As such, I believe you will be interested to know that as NASA is now organized, there are life science responsibilities in three of the four major program offices. In the Office of Manned Space Flight, there is a Division of Aerospace Medicine. In the Office of Space Sciences, we have a Division of Bioscience Programs, and in the Office of Advanced Research and Technology, we have an office devoted to pure aerospace medical research.

Only in the area of practical applications of space science and technology -- where we are working toward operational systems of communications and meteorological satellites -- do we have no life science activity. Perhaps even in these areas, perhaps to operate service stations for satellites in space, we may have to add life science activity. But at the moment, this program office has no responsibility in the life sciences.

In the Office of Manned Space Flight, the Aerospace Medicine Division ranks with such major divisions as Launch Vehicles and Propulsion, and Spacecraft and Flight Missions. Formerly, all this activity was part of the Office of Life Science Programs. The transfer of aerospace medicine to the Office of Manned Space Flight emphasizes that the objectives and responsibilities of aerospace medicine in NASA are mission-oriented, to insure the safety, health, and reliability of flight and ground crews during the preparation and

and conduct of manned space flight missions.

Everyone who followed the Shepard, Grissom, and Glenn missions on television or in the press obtained some insight regarding the role of aerospace medicine in these pioneering flights. The coverage of these flights clearly showed the importance of the Mercury system for continuous monitoring and recording of the astronauts' physical conditions and their responses to acceleration, weightlessness, and other conditions of space flight that differ from the normal environment of man. This coverage also gave an appreciation of the extensive aerospace medicine developments of protective clothing, individually adapted methods and devices for support in re-entry or emergency deceleration, and back-up systems in support of primary ones.

And aerospace medicine will play an increasingly important role in the more advanced projects now under way: the use of a modified Mercury spacecraft for a one-day orbit mission, the two-man Gemini project, which will extend the time of weightlessness to a week or more; and, of course, Project Apollo, which has as its ultimate goal a manned lunar landing, exploration,and return.

These projects sum up to an active space-flight program, with missions every 60 to 90 days, and a continuous feed-back of the experience gained as to how many men on many flights react to the conditions encountered.

For long flights, the present Mercury 100-percent oxygen environment may need the addition of nitrogen; or the present pressure of 5.1 pounds per square inch may need to be increased. As we proceed step-by-step to gain experience and skill with the flight capability of spacecraft and boosters, and learn how to improve our launching and recovery systems, we will also drive ahead to develop, through aerospace medicine, the know-how that will continue to make more effective utilization of men in space and give them ever greater protection from its hazards.

NASA's ability to move ahead with its part of the National Space Program has been tremendously strengthened by the pioneering efforts and many years of investigation of man's role in space carried out by the Armed Forces.

Brigadier General Charles H. Roadman, United States Air Force is director of the Aerospace Medicine Division of NASA. This division has two main functions. One is development, testing and evaluation of equipment, techniques, and systems needed to assure the effective performance and safety of flight and ground crews. The second is operational medical support of flight missions.

Under the function of development, there are three major areas:

1. Provision of aerospace medical data during the planning stage of a flight mission. This data includes the limits and tolerances of human beings to the stresses of space environment, such as acceleration, weightlessness, and radiation.

2. Development of systems and components which can be integrated into the various spacecraft configurations at the proper time. These include the development of atmospheric and environmental systems, waste-control systems, pressure suits, crew equipment, survival and recovery aids, and means for supplying food and water.

3. Testing and evaluation of these systems and their components to assure that they will perform as intended and reliably when they are integrated into the over-all systems of the spacecraft.

Under the function of operational medical support, we include these highly important tasks:

1. Medical selection of flight crews and various functions of observation, care, and training of the crews from the time they are selected through their employment in actual space missions.

2. Medical monitoring, which includes provision of flight-ground instrumentation as well as trained medical personnel at ground stations to monitor and record medical conditions of the crews during every phase of flight.

(This was a difficult enough task for a three-orbit flight, such as that of John Glenn. It is going to be an operation of much greater scope and complexity when we have two or men in orbit for a week or more, and when we begin actively to investigate the effects of escape velocity and reactions during return to the atmosphere from a lunar trip, or simulated lunar trip.)

3. Recovery operations to assure that competent medical care is available in recovery areas around the world.

4. Medical data collection, analysis, and dissemination to increase the knowledge of the effects of space travel on men, to aid in design of more advanced spacecraft systems, and in planning for future missions.

In the Office of Space Sciences, the specific objectives of the Division of Space Biology is the search for extraterrestrial life and the study of the effects of strange environments on living organisms, particularly those which we believe to exist in space, on the moon, and on the planets.

An important part of the search for life on the planets, prior to manned landings, is to establish with some assurance what sort of life forms may or could exist.

In our program in evolutionary biochemistry, we are trying to recapitulate in laboratories on earth chemical events which transpired two or more billion years ago in the earth's primeval atmosphere.

In our space and planetary simulation studies, we try to produce likely planetary environments here on earth, to find what life forms familiar to us will grow under such conditions. We already have a list of 18 microbial candidates to look for on Mars, for example.

We also have under development a number of ingenious devices which, if landed on Mars, could report back whether they find evidence of life similar to those we might logically expect.

One of the most interesting experiments is what we call the "sticky string," a small dome-like device to be landed on Mars in 1964 or 1966. When it lands, it will shoot out two adhesive-coated strings, about 100 feet long, which will be wound back into a nutrient solution containing radioactive carbon. If microbes such as we know on earth are captured, they will begin to multiply in the nutrient solution, and radioactive carbon dioxide will be produced. This gas will activate a counter and transmit radio signals that will reach earth monitoring stations.

As few as five microbes trapped on the strings could produce a signal within nine hours -- if they like the meal prepared for them. If such microbes are plentiful on Mars, the signal should come to earth in an hour or less.

We are also very much interested in a high-altitude balloon flight scheduled for early next year. It will carry highly sensitive new instruments for a spectroscopic examination of Mars for evidence of life.

Our program for conducting space biology experiments by using space probes and satellites is just getting under way. A probe into the inner part of the Van Allen Belt is planned to study the lethal and hereditary effects of radiation on standard biological specimens such as live blood cells, cereal seeds, molds, bacteria, and insect eggs. The effect of zero gravity on complex cell division, on one-cell animals, and on the synthesis of proteins from amino acids will also be investigated. Later, we hope to place fairly large numbers of specimens in a recoverable satellite to determine the effects of prolonged periods of weightlessness on many other biological processes.

For the first time in millions of years, these biological processes will be operating or will try to operate in the absence of gravity. We hope to learn many new things about the nature of living processes and utilize this new information to achieve progress in manned space flight.

The wide variety of experiments we are making in space biology will have a deep impact, not only on biology itself, but on science as a whole. One of the next great discoveries of our era may well be the obtaining of convincing evidence that the earth is not the only seat of life of some form in the solar system. Another may well be new knowledge of the adaptability of many of the life forms we know on earth to entirely new conditions not known on earth.

The third form of NASA life science activity will be in the Office of Bioresearch and Technology, which we are activating within the Office of Advanced Research and Technology.

This new office will be primarily concerned with the medical and bio-engineering problems connected with space plans beyond the lunar landing -- with such items as large manned orbital laboratories, lunar bases, and planetary flights.

The Aerospace Medical Division of NASA is utilizing to the maximum the facilities and resources available within the Department of Defense and the Atomic Energy Commission, as well as within industry and the universities. This is in line with the policy not to duplicate existing resources, but to develop in-house capability sufficient to conduct, manage, and evaluate the NASA programs effectively, utilizing wherever possible the resources of other agencies, industry, and the universities.

Certain of the responsibilities for in-house testing of manned space flight equipment and its evaluation will fall on the NASA Manned Spacecraft Center at Houston, with assistance from the Ames Research Center at Moffett Field, California.

It is certainly obvious to every member of the Aerospace Medical Association that before work in the life sciences, and particularly the flight program involving men and specimens, could go forward, an extensive investigation of the phenomena of the space environment was required.

Beginning with balloons, and continuing through the 45 years from the flight of the Wright brothers to the availability of modern jet aircraft, man has constantly improved his machines to overcome the pull of gravity and to transport devices farther and farther from the earth to make scientific measurements. But it was only with the advent of the modern rocket, which does not require the oxygen of the air to combine with its fuel to develop its power, nor the medium of the air as a working fluid, that man could transport measuring devices out beyond the blanket of the earth's atmosphere. This meant that the period when man was confined to making observations of phenomena in space through the distortions of the earth's atmosphere ended, and instruments could be sent out to make specific and detailed measurements of a wide variety of phenomena and return this information to earth.

To you, as men of science, it is interesting to note that in this case the technology required to make and fly powerful rockets, involving the most efficient use of energy, new lightweight materials, and very complex systems of electronics, had to precede the scientific work which these rockets made possible. It is an interesting fact that a very large part of the work of the National Aeronautics and Space Administration is devoted to the technology of the rocket and, therefore, a large proportion of the cost of the nation's space program goes to build, launch, keep track of, and use the modern rocket.

We all know that the first 60 years of this century have been years of revolutionary change. Empires have fallen. Upheaval has shaken such vast regions of the world as Russia, China, the Middle East. New nations are emerging in the less developed regions. Communist dictatorships have arisen to challenge constitutional democracy and the right of peoples to self-government or national self-determination.

Paralleling the political upheavals, there has been an all-pervading scientific and technological revolution. Most of the technology basic to teleradio communications developed during this century. So did the growth of the automobile industry, of aviation, and the applications of nuclear energy. In the same period, came the development of the modern rocket, with the characteristics and potentialities I have already mentioned, but with still another, of great significance: with increases in size, even to giant proportions, efficiency in space increases at a very rapid rate. So also do the problems of fabrication, handling, transporting, and launching on earth.

Increasingly, as the scientific and technological revolution gained momentum, the Government has found it necessary to engage in large-scale activities of scientific research and development. We began this in World War II, with the Manhattan District atomic energy project carried out by our military services. But after the war, and responsive to the outcome of a great national debate, Congress passed an Act that placed atomic energy d evelopment under a civilian agency. Military requirements were to be satisfied, but the Act specified that efforts which would not violate security should be applied through the Commission for the general welfare.

A few years later, in the broader fields of all the sciences, the 1950 Act creating the National Science Foundation established the goal of stimulating science for the general welfare.

In the 1950's, as rocket developments progressed and gave promise of opening the Space Age, we passed another milestone.

In 1958, Congress decided to create a new civilian agency of Government, which would have thorough scientific and technological competence in the aeronautical and space fields. Again, Congress acted to provide that this new area of science and technology would be used for the general welfare.

The new agency, which I have the honor head, the National Aeronautics and Space Administration, was built around the National Advisory Committee for Aeronautics, the Jet Propulsion Laboratory of the California Institute of Technology, and the Army's von Braun group at Huntsville, Alabama.

The law requires of NASA a long-range plan, and this was established under the previous Administration. That plan laid out a progression of space research and exploration events toward which to work over a period of 15 years.

Last year, when faced with ever more rapid Soviet progress in space, and with new opportunities opening up from our own progress in science and technology, President Kennedy reviewed this long-range plan. He determined with the help and advice of Vice President Johnson and the National Aeronautics and Space Council, that it is feasible to compress the 15 years of effort called for under the old plan into a decade under a new plan. The President proposed, and Congress endorsed a program to do just that.

But there is a factor which must not be overlooked. Science and technology, and the means to develop and utilize them have undergone a radical change. Perhaps the best way I can express this briefly is to quote from the Chairman of the Space Science Board, Dr. Lloyd V. Berkner:

> "At the turn of the century, our science, though useful, was limited in its ability to understand, interpret and predict natural events. ...it had guided our creation of elementary machines, and primitive electric communications. But in a real sense, these were merely superficial developments of the more obvious and elemental manifestations of nature. We simply did not understand the deeper organization of nature -- how it was basically composed, how it behaved fundamentally. Therefore, the ultimate development

of the industrial revolution was sharply bounded by the mere mathematization and efficient organization of what man had already learned to do over the ages.

"But with the unfolding of the twentieth century came a remarkable series of scientific discoveries. In 1905, Einstein created the relativistic mechanics which revealed the true four-dimensional character of our universe and predicted the identity of mass and emergy. In the same year, he showed from the photoelectric effect that energy is not continuous but comes in tiny but discrete packages, just as matter is subdivided into elemental atoms and electrons. In 1911, Rutherford discovered the atomic nucleus, and in 1913, Bohr described the atom as a nucleus encompassed by electrons held in fixed orbits or shells. In 1924, Heisenberg formulated the principle of uncertainty, when for the first time science learned of the limits beyond which cause and effect were no longer meaningful. In 1926, deBroglie formulated, and then Schroedinger and Dirac elaborated the wave-mechanics which could describe the behavior of matter with mathematical precision.

"In 1932, Chadwick discovered the neutron, and in 1939 Hahn and Strassmann produced atomic fission whereby mass was converted into energy, thereby fulfilling Einstein's earlier prediction. Step-by-step in a mere 35 years, a whole new concept of the physics of nature emerged. This was a different and more powerful physics that not only encompassed the classical physics, but also gave a completely new and very deep insight into nature.

"Another example of the departure from classical methods occurs in our present description of the behavior of particles. Some obey a Fermi statistics and some a Bose statistics, depending upon their intrinsic angular momentum -- again a demonstration of how our conception of physical reality is sharpened by new approaches."

Dr. Berkner goes on to show that through "the formulation of Information Theory by Claude Shannon in 1948 -- a mere 14 years ago. ...man acquired the knowledge and methods to build the modern computer in a completely logical way, and thus acquired the means by which to employ his new and abstruse physics in practice. He concludes that man is now "at the threshold of a new revolution in technology," which "is very different in character from the old industrial revolution. It is based on a completely new insight into nature, and the new ability to uncover otherwise hidden natural phenomena and to manipulate natural processes that were hertofore inconceivable."

In space, the modern rocket supplies, to repeat Dr. Berkner's words, "the new ability to uncover otherwise hidden natural phenomena and to manipulate natural processes that were heretofore inconceivable."

Using the rocket to take advantage of scientific methods in space, the space science program is a quest for fundamental knowledge, which we undertake on its own merits as research. Without programs for basic research, our reservoir of knowledge, from which all technological, or practical, developments must grow, would soon run dry.

It may sound paradoxical to laymen, but you will understand that in the long run most practical benefits from space will be attained from research in areas in which we have no advance assurance of success. The only way we can really advance knowledge is to explore the unknown. If we only investigated areas where we knew what we could expect to learn, we would miss many new and valuable clues to a broader understanding of nature's basic laws and of how to use them for practical benefits.

Let me give you an example. Suppose we had laid out a program five or six years ago directly tied to manned space flight. This program would not have included the instruments which discovered the Great Radiation Belt, which not only constitutes one of the severest manned flight problems we face, but is also a phenomenon of the near-space region around the earth which we must measure and understand to take the next steps in many other fields.

Five years ago, the prevalent scientific opinion was that cosmic rays would be no hazard to manned space flight.

But because science knew so little about cosmic rays, the first U.S. satellites were instrumented to learn more about them. As a result, Dr. Van Allen was able to discover the great radiation blanket about the earth. There may be other hazards to man-in-space, whose existence we do not even yet suspect. And the way to learn of them is to carry out basic research in space, coordinated with an active experimental space-flight program, now that we have the capability.

The space science program has a very broad scope. It covers many disciplines, including physics, the biological sciences, chemistry, and astronomy. It crosses the specialty lines, bringing together scholars in widely differing fields. It will stimulate and contribute to the entire spectrum of knowledge, increasing its usefulness here on earth as well as out in space.

Although we know that the solar system was formed more than four billion years ago, <u>how</u> it was formed is not known, although it has been the subject of much thought and speculation for centuries. Investigation of the origin of the solar system by instruments carried to the moon and other planets is of the greatest scientific importance here on earth.

For some space observations, we employ sounding rockets, which fire up through the atmosphere recoverable payloads that do not go into orbit. Sounding rockets make observations beginning at 20 miles altitude and going out as far as one earth radius, or 4,000 miles. For obtaining information in the region between 20 and 100 miles altitude, sounding rockets are launched, sometimes as frequently as once a day, from the NASA station at Wallops Island, off the shore of Virginia.

In experiments at altitudes above 100 miles, but still relatively near the earth, instrumented satellites also are used to gather information. While the flight of a sounding rocket is very short, that of a satellite may extend over a period of days or even years.

To the more distant reaches of the solar system, we launch a different device, called a deep-space probe. One of these, Pioneer V, told us by radio about conditions in space 22½ million miles distant from the earth.

Satellites and sounding rockets also enable us to investigate the earth itself from a new vantage point. We are now able to learn enormously more than was previously possible about the structure and composition of the upper atmosphere, the ionosphere, charged particles, meteoric dust, cosmic rays, magnetic storms, and the workings of the weather near the earth's surface.

For example, we have developed new scientific information on earth-sun relationships -- the effect of the sun's activity on conditions on earth, particularly radio communications and the weather. Interest in this subject has grown tremendously in the last few years, now that rockets and satellites are available for investigating conditions above the top of the atmosphere.

Although most energy from the sun reaches us in the form of visible light, at a constant rate, some of the solar output fluctuates violently. This solar activity may affect the weather. Scientific understanding of the complicated processes of the weather is still very incomplete. The earth's atmosphere is a great heat engine, driven by the energy from the sun. Operation of the engine is affected by evaporation and condensation of water, filtering of radiation in various wave-lengths by the gases in the atmosphere and ionosphere, and reflection and absorption of heat and other radiation by the surface of the earth.

We can observe conditions directly with the weather satellites -- TIROS and the coming Nimbus and Aeros types. But we are also carrying out investigations of the sources of the weather by monitoring the sun and observing how it affects the upper atmosphere. The experiments employ satellites, sounding rockets, and flights into deep space.

By means of rocket-launched instruments, scientists are now able to look at the sun and stars without the distortion and interference of light and other radiation that takes place in the atmosphere. Revolutionary advances in astronomy are expected in the next few years, as these investigations in space continue.

Now that more powerful rockets are becoming available, we are planning larger scientific spacecraft, which will carry a multitude of scientific experiments. These are called Orbiting Observatories. The first, the Orbiting Solar Observatory (OSO), was launched March 7, carrying many devices to learn as much as possible about the sun. The OSO marks a major step forward in our ability to investigate space and our environment. It weighs 458 pounds and is in an orbit about 350 miles above the earth. There are 13 scientific experiments aboard, some on a spinning section and some on a section pointed permanently toward the sun. The satellite carries solar cells that supply electric power for all of these experiments, and bottles of nitrogen that provide thrust to correct orientation.

OSO instruments point so accurately at the sun that if the automatic pilot of an airplane, taking off from Los Angeles, were set on a New Jersey airport with this accuracy, and the course were unchanged, the plane would arrive within a mile of the spot intended.

The experiments aboard OSO are seeking to learn the causes of solar storms and other sun phenomena. It will provide more detailed understanding of the earth, the sun, the earth-sun relationship, and the universe itself. Additional launchings of OSO will take place over the next 11 years, to cover an entire solar cycle.

In addition to the OSO, beginning next year, we shall launch Orbiting Geophysical Observatories, carrying instruments to investigate phenomena near the earth and in the space adjacent. In late 1963 or early 1964, NASA plans to put into space the Orbiting Astronomical Observatory, which will carry a 36-inch reflecting telescope and other instruments to learn about the distant reaches of the universe.

The moon is a primary target of our investigations because it may hold the answers to the secrets of the origin of the solar system. Here have been preserved the records of lunar history for many millions of years because on the moon there is neither atmosphere nor water, nor are there winds to erode the surface. Exploration of the moon will carry scientific investigations of the universe we live in much further into the past than would ever be possible on earth.

We also plan to investigate the internal structure of the moon by landing a seismometer to record and transmit information on moonquakes and shocks caused by meteorite impacts.

Data on the lunar structure is much needed for study of the early history of the solar system and the birth of the planets.

NASA's first program for unmanned investigation of the moon is Project Ranger, in which a 325-pound pack of scientific instruments will be landed. We have already carried out three experimental flights which did not make lunar landings. Six more are planned for 1962 and 1963.

The first Ranger to land on the moon will measure moonquakes and surface temperatures. Later, Rangers will carry a TV system that will transmit to earth the moon's surface features in much finer detail than it is possible to obtain with earth-based telescopes.

The Surveyor project will follow Ranger. Flights are planned for 1963 through 1965. The Surveyor has two versions. One will make a soft landing on the moon, unlike the Ranger, which will land at about 200 miles an hour. The 350-pound spacecraft will make detailed studies of the moon's surface and environment, will drill and analyze soil samples, and will televise pictures back to the earth. A second version of Surveyor will make orbital flights around the moon for extensive mapping.

In the planning stage is a still larger vehicle for landing on the moon, Project Prospector. Prospector may be employed to transport an unmanned vehicle that can move about on the moon's surface. This spacecraft may also carry heavy payloads to support both unmanned scientific and manned explorations of the moon.

All our unmanned lunar investigations are clearly important to the manned lunar exploration that will follow them.

In addition to the lunar program, the NASA space science program includes planetary and interplanetary investigations.

For this summer, when there will be an opportunity to launch spacecraft toward Venus, we have scheduled two flights in Project Mariner. A more advanced version of the Mariner spacecraft will be employed for both Mars and Venus missions, beginning in 1964 and extending at least through 1968. A still larger spacecraft will be designed in Project Voyager to go into orbit about these planets.

One of the Mariner spacecraft in 1964, and later Voyagers, will carry a landing capsule, which is designed to obtain detailed measurements and land life-detecting instruments on the planets.

As you know, NASA is pursuing a program of direct practical applications of space technology. Last year we began developing three major communications satellite concepts -- two designed for use in low orbits, and one for use in high-altitude synchronous orbits in which the satellite revolves around the earth every 24 hours. Its orbit being thus synchronized with the rotation of the earth, the satellite remains stationary over one point on the earth's equator. The low-altitude projects are Relay, financed by the Government, and Telstar, financed by the American Telephone and Telegraph Company. The Syncom, or synchronous-orbit satellite, is financed by the Government and is coordinated with the Advent military communications program, a high-altitude synchronous satellite system being developed by the Department of Defense.

NASA is also continuing research in the large balloon communications satellites, with the 135-foot Echo II.

Another practical application of satellites is for weather observation and prediction. We have now had four successful TIROS satellite launchings in four attempts. The third TIROS, launched last summer in time for the hurricane season, reported the existence of dozens of storms in advance of conventional ground-based observations. Last winter, the fourth TIROS provided information on ice conditions in the St. Lawrence. In at least seven cases, information obtained by this satellite has enabled significant adjustments in the weather analyses by the U.S. Weather Bureau. The analyses are employed by the airlines in scheduling flights, and, indeed, were used in scheduling John Glenn's orbital flight of February 20.

We will be working with the Navy in connection with civilian utilization of the Transit satellite which has demonstrated that it has great value to our military services for navigation and which many believe will have wide commercial applications.

A third major area of the NASA program is the development of boosters, spacecraft, and operational methods for manned space flight. Men aboard spacecraft will provide the ability to observe phenomena in space and will increase the reliability of spacecraft systems.

Even the most advanced instruments can gather and transmit only information that they are programmed to obtain. They have no flexibility to meet unforeseen situations. We have had almost 70 successful unmanned spacecraft to date, but none of their instruments reported the "fireflies" that John Glenn saw on his February 20 flight in orbit.

You may be interested to know that the scientists have called these fireflies the "Glenn effect." There is still no agreement on what they were. Dr. John O'Keefe, a scientist at the NASA Goddard Institute of Space Studies, believes that they probably resulted from particles of paint flaking off the capsule. John Glenn, however, disagrees. We shall perhaps have a firm interpretation after the next flight -- if the phenomenon occurs again.

When our investigations extend out to the moon and planets, man will be ever more needed as the distance and difficulty of missions increase.

John Glenn demonstrated how man can increase the reliability of a spacecraft system. There were malfunctions in the automatic attitude control of his Friendship 7 capsule, but he was able to take over manually and continue the flight. If an astronaut had not been aboard, it would have been necessary to bring the craft down after one or two orbits, and we would not have learned much that we now know about the problems and solutions of manned space flight.

We have had a wealth of similar experience with the X-15 research aircraft, which has penetrated outward to the fringes of space at speeds of more than 4,000 miles per hour. Many X-15 missi ons would have failed if there had not been a pilot in the cockpit to correct malfunctions of equipment, instruments, or powerplant.

The Friendship 7 flight accomplished the initial objective of Project Mercury, first phase of the manned space flight program of the United States. Further three-orbit flights will be conducted this year, at intervals of 60 to 90 days. As you probably know, Scott Carpenter has been selected to make the second flight, which is not far off.

The basic Mercury spacecraft is being modified to allow orbital flights lasting up to one day. Following this will come Project Gemini, in which we are developing a two-man spacecraft with the capacity to remain in orbit up to a week, to obtain experience with longer periods of weightlessness.

Gemini will also make it possible to conduct experiments in manned rendezvous and docking in orbit about the earth. The joining of two objects in earth orbit would permit rescue, crew transfer, or repair operations in space, and would lead to establishment of a permanent space platform in orbit. Some problems inherent in our mission to the moon can be greatly simplified by the rendezvous technique, shortening our time schedule by as much as two years. The Gemini program will enable us to experiment with this technique at much less expense than would be the case if we waited until the Apollo were available.

To carry out these rendezvous experiments, we shall employ an Atlas booster to launch an unmanned Agena B space engine into orbit. When this orbit has been determined carefully, a Titan II will launch a manned Gemini into the same orbit, so that the Gemini and the Agena B space engine can be maneuvered and coupled in space. Gemini astronauts will control the final phase of this operation -- while traveling at speeds of nearly 18,000 miles an hour.

Project Apollo is our program for manned landing on the moon. The three-man spacecraft that will return to the earth from the moon will weigh about six tons. To lift this mass from the moon and launch it back to the earth, we must have a lunar-escape craft, including rocket and fuel, with an earth-weight of about 60,000 pounds.

But the moon has no atmosphere and so the lunar craft must back down to the moon with braking rockets. To provide the necessary reverse thrust, we must launch 150,000 to 200,000 pounds to the vicinity of the moon. That, in turn, requires about 350,000 to 400,000 pounds of payload in orbit about the earth.

To launch directly toward the moon on this mission would require the thrust of the giant Nova booster, which will stand about 350 feet tall, and would weigh about 10 million pounds. We are carrying out studies that will lead to contract awards for developing the various stages of Nova, the first of which will generate approximately 12 million pounds of thrust.

With use of rendezvous, however, it may be possible to launch the moon expedition in two stages with a somewhat smaller launch vehicle, the Advanced Saturn. I do not want to leave the impression that Advanced Saturn is actually small, except in comparison with Nova. It is almost as tall as the Nova and its first stage will generate thrust of 7½ million pounds. Development of the Advanced Saturn is already under way.

In the first phase of Project Apollo, we plan to launch the three-man spacecraft into earth orbit. We have already made one flight test of the first stage of the Saturn C-1, which will be the launch vehicle for that mission. Another Saturn test-flight is due in a few weeks.

The second phase will consist of flights deeper and deeper into space, culminating in a manned flight around the moon. The Advanced Saturn will provide power for that part of the program.

Finally, we plan to employ two Advanced Saturns to launch the expedition to the moon. At first, a large, fully fueled space engine will be launched into orbit about the earth. After that orbit is carefully measured, another Advanced Saturn will launch the manned spacecraft into the same orbit and the two will make rendezvous and dock together. At a carefully calculated moment, the large rocket stage will be ignited and the three-man expedition will proceed to the moon.

If the techniques of rendezvous cannot be developed on time, Nova will provide the power for direct flight from the earth to the moon.

The fourth major area of NASA interest is advanced research and technology. Major divisions of this work include nuclear systems, vehicle design, propulsion and power generation, electronics, and control, and, as I mentioned earlier, bio-research and bio-technology. In addition, we carry out an extensive program of aeronautical research.

All these investigations are significant, but I believe the work in nuclear propulsion under Project Rover deserves special attention. The Rover program, in which NASA and the Atomic Energy Commission are cooperating closely, has emerged as a major phase of the national space effort.

The nuclear rocket, as you may know, employs the energy of an atomic reactor to heat hydrogen gas, which is then expelled through a nozzle to provide thrust. The goal of Project Rover is development of an upper-stage nuclear rocket compatible with the Advanced Saturn, which will take advantage of the greater fuel economy that is theoretically possible with nuclear propulsion.

We are working toward a flight-test of the Rover nuclear rocket in the 1966-67 period.

The space program of the United States, as I have mentioned, is national in scope. NASA works with, and has the support of, the Department of Defense, the Atomic Energy Commission, the Weather Bureau, the Coast and Geodetic Survey, the Federal Communications Commission, the Bureau of Standards, the National Science Foundation, the Smithsonian Institution, the Federal Aviation Agency, and other Government agencies.

Moreover, the work is done across the country in industry, in universities, in non-profit laboratories as well as by the Government. In President Kennedy's budget request for the 1963 Fiscal Year, more than 90 percent of the funds requested for NASA would go to non-governmental contractors, with a large proportion in contracts to small business.

We must not forget the symbolic value of space exploration. There is a general feeling around the world that the country which is most successful in space exploration has, therefore, proved a greater total scientific and technological strength. As a nation, we cannot accept second best in what has been termed "the greatest adventure ever undertaken by man."

It has been a great pleasure to be with you today. In closing, I would like to quote Representative George Miller, Chairman of the House Space Committee, who said recently:

> "Our need to lead in space exploration is not merely a matter of space survival; it is not simply the result of a selfish desire for the yet undreamed-of conveniences and luxuries which the mastering of space technology can create.
>
> "It arises from a broader and nobler purpose which has existed in the hearts and minds of men since the first human thought occurred -- the need to know, the need to grow, the desire for fulfillment of the ultimate destiny of mankind."

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